

Critical Minerals: A Matrix and 4 Propositions

Roderick G. Eggert
Division of Economics and Business
Colorado School of Mines
reggert@mines.edu

Presented at “Minerals for a Green Society,” organized
by MMSA, Washington, DC

February 4, 2010

Context

➤ Demand

- Material composition increasingly complex
- Potential rapid growth in demand for some minerals

➤ Supply

- Seemingly increasingly fragile
- More fragmented supply chains, US import dependence, export restrictions on primary raw materials, resource nationalism, increased industry concentration

Possible Effects of Supply Restriction

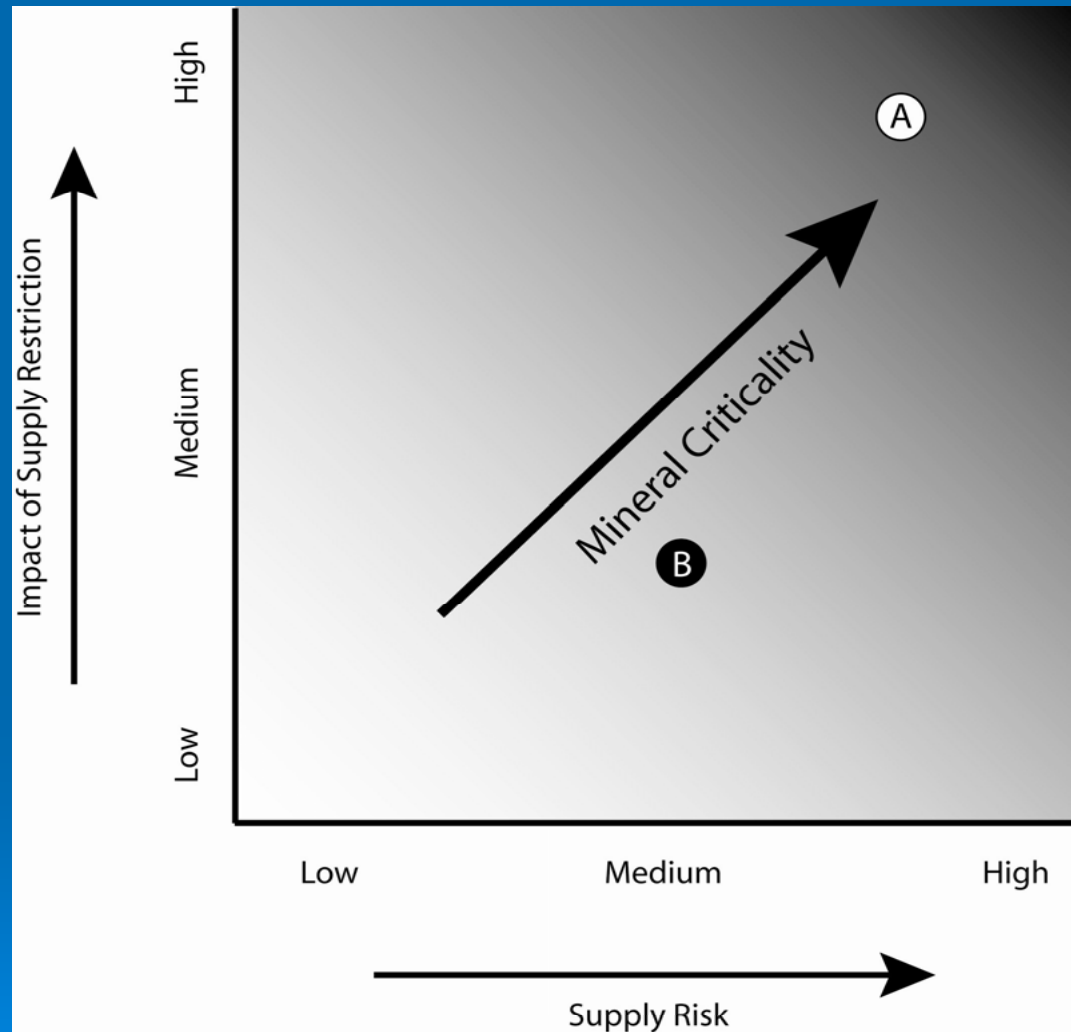
➤ 2 forms

- Higher mineral prices
- Physical unavailability

➤ Possible economic consequences

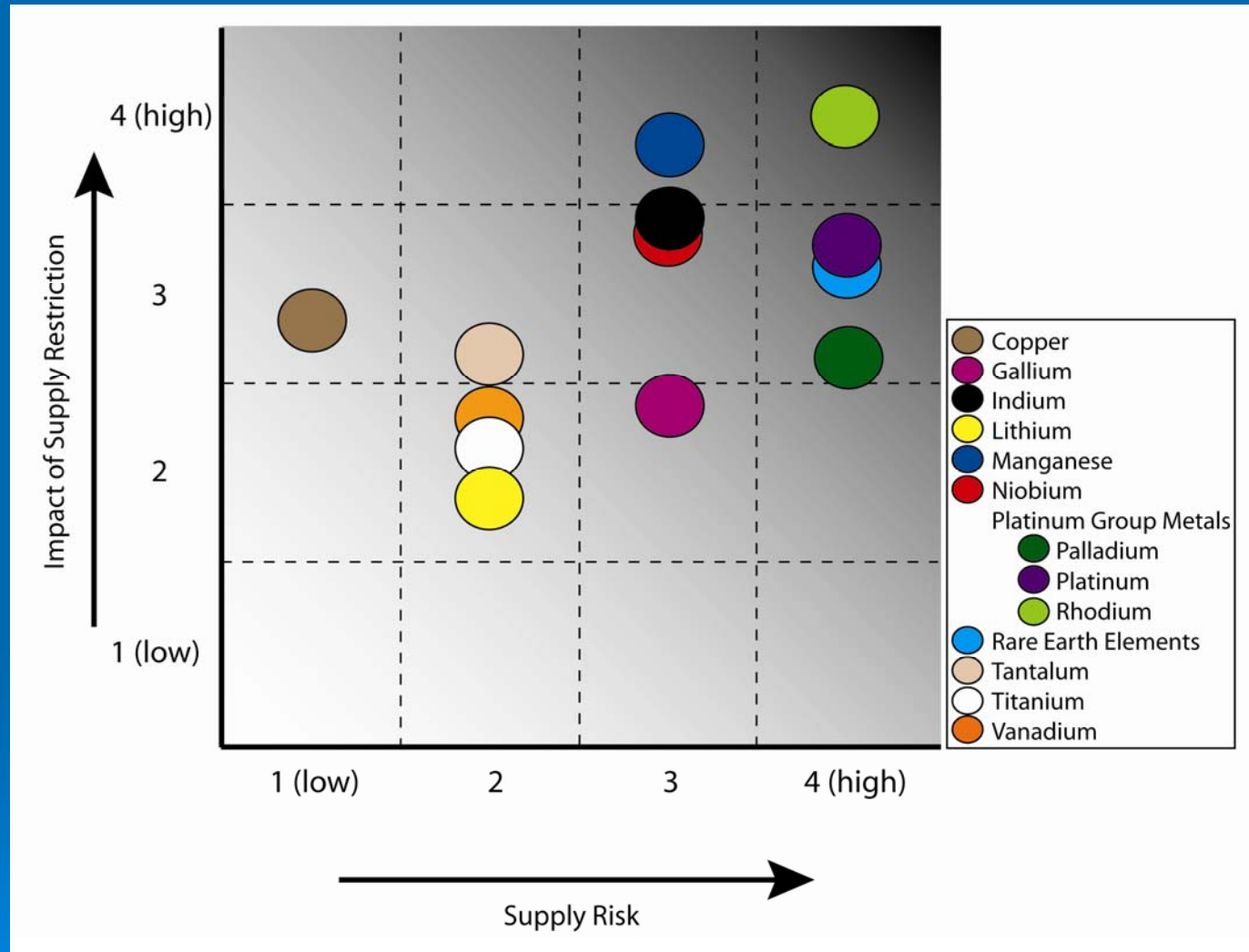
- *Firm*: “no build” situation, higher input costs
- *Industry*: lower output & profitability, use restricted to higher-valued applications, slower growth in emerging applications

Analytical Framework: Criticality Matrix



Source: US National Research Council, *Minerals, Critical Minerals, and the US Economy* (2008).

Minerals Evaluated



Source: US National Research Council, *Minerals, Critical Minerals, and the US Economy* (2008)

Proposition #1: Limits on mineral-resource availability. . .

- . . .are more about costs, distribution, and time frame than about tonnes

Reserve/Production Ratios

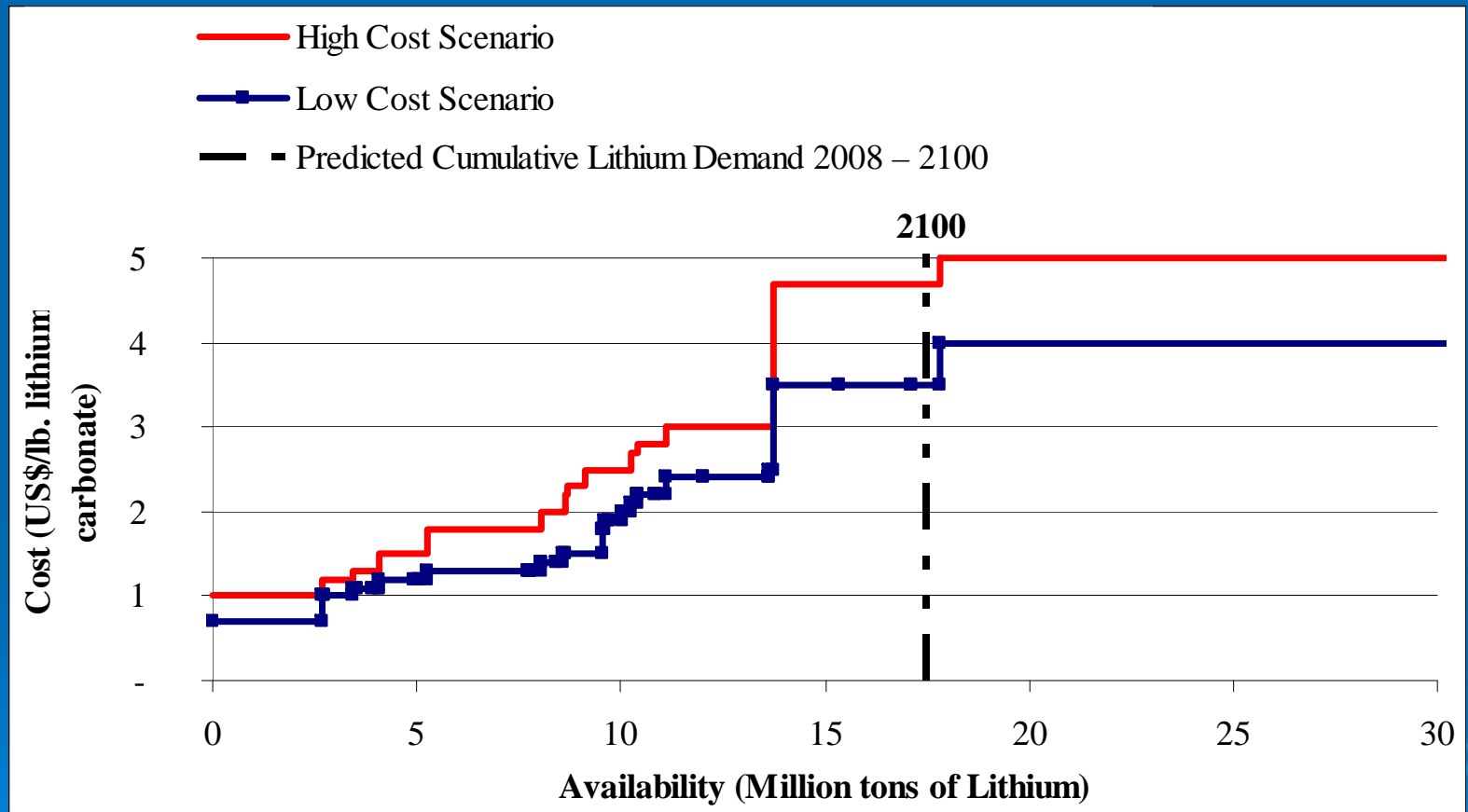
(years remaining at then-current production rates)

	1978	1995	2008
Crude oil	29	41	42
Cadmium	38	29	24
Cobalt	94	205	99
Copper	65	32	35
Iron ore	183	150	68
Lithium	na	350	150
Molybdenum	92	47	41
Rare earths	221	1,390	710

Sources: BPAmoco, US Geological Survey,
US Bureau of Mines

Lithium: Cumulative Availability

(high and low cost estimates, projected cumulative demand to 2100)



Source: Yaksic and Tilton, 2009.

Rare Earths, 2008

	Mine Production (mt)	Reserves (000 mt)	Reserve Base (000 mt)
Australia	---	5,200	5,800
Brazil	650	48	84
China	120,000	27,000	89,000
CIS	NA	19,000	21,000
India	2,700	1,100	1,300
Malaysia	380	30	35
USA	---	13,000	14,000
Other	NA	22,000	23,000
Total	124,000	87,378	154,219

Source: US Geological Survey, www.minerals.usgs.gov

The Temporal Dimension of Security of Supply

- Short- to medium-term reliability (up to a decade)
 - Not simply a matter of import dependence
 - Rather, risk factors such as:
 - Small existing market, rapid increase in demand
 - Concentrated supply (mine, company, or country)
 - Byproduct supply
 - Little or no spare capacity
- Long-term availability (more than a decade)
 - Not simply a matter of limited reserves today
 - Rather, depends on:
 - Geologic and technical considerations

Proposition #2: Market pressures are effective in encouraging. . .

- . . .investment that re-invigorates supply
- . . .users to provide 'insurance' against supply risks

- Caution: market adjustments take time and often are chaotic

Potential New Suppliers of Rare Earths

- Advanced exploration and development projects
 - Heavy rare earths
 - Thor Lake, NWT (Avalon Rare Metals)
 - Hoidas Lake, Saskatchewan (Great Western Minerals Group)
 - Bokan Mountain, Alaska (UCOR Uranium)
 - Strange Lake, Quebec (Quest Uranium)

Potential New Suppliers of Rare Earths (continued)

➤ Light rare earths

- Mountain Pass, California (Molycorp)
- Lemhi Pass, Idaho (Thorium Energy)
- Mt Weld, Western Australia (Lynas)

➤ Important investment considerations

- How sustainable is demand growth?
- How technically sustainable is low-cost, high-quantity Chinese production?
- How politically sustainable are Chinese export restrictions?

Rare Earth Users

- Short to medium term
 - Diversify sources of supply
 - Invest in alternative sources of supply
 - Develop tighter relations with suppliers
 - Develop joint sharing arrangements
 - Maintain stockpiles
- Long-term substitution

Substitution Examples

➤ Molybdenum

- Price up 6x, 1978-79
- Led to more efficient use in alloyed steels; more heat treating allowed 25% reduction in Mo per unit of alloyed steel; not reversed when P fell

➤ Cobalt

- Price up significantly in 1978-79 due to demand increases and supply problems (civil unrest in central Africa)
- Reaction: increased R&D in aerospace/defense sector
- Substitution: Co-free ceramic magnets, other alloying elements (e.g., Ni)

Source: Crowson, pp. 40-44

Proposition #3: Chinese mercantilism should be. . .

- . . . a concern not an obsession
 - Yuan arguably undervalued even though it has appreciated 20% against the US\$ in last 4 years
 - Export restrictions on some raw materials benefit Chinese manufacturers of export goods
- Note: Similarities between China today and Japan in 1970s

Proposition #4: Government activities should focus on. . .

- ...encouraging undistorted international trade
- ...ensuring that policies and procedures for domestic mineral development appropriately integrate commercial, environmental, and social considerations
- ...facilitating provision of information on which private and public decisions are made
 - Including basic information on long-term availability and supply (geologic resources, above-ground stocks)
- ...facilitating research and development
 - Especially on recycling of specialty metals used in small quantities in emerging uses

Extra Slides

United States

- Historically, national defense (military) stockpiles, some support for basic research
- Otherwise, private entities responsible for own 'insurance'

US National Defense Stockpile

- April 2009 Report to Congress
- Finding: transform stockpile into a broader Strategic Materials Security Program
 - Integrated risk assessment
 - Continuously monitor global markets
 - Establish supply chain commitments with suppliers
 - Monitor performance
 - Store only limited amounts and types of materials

Source: *Reconfiguration of the National Defense Stockpile Report to Congress*, April 2009.

Other Recommendations for Stockpile

- Suspend temporarily or limit the sale of 13 stockpiled commodities
 - Be, Cr, Nb, ferrochrome, ferromanganese, Ge, Ir, Pt, Ta, Sn, W, Zn
- Monitor 39 other materials as candidates for future supply-assurance activities
- Assess strategic sourcing of materials used in largest quantities by DOD (ranked by tons)
 - Al, Cu, Pb, fluorspar acid grade, Zn, PGMs, Mn ore chem/metal grade, Ni, ferrochrome, chomite ore, Ti sponge

European Commission

- November 2008 raw materials initiative
- Motivation: export restrictions by exporters of raw materials threaten viability of European manufacturers
- 3 principles
 - Obtain undistorted access to raw materials on international markets
 - Develop a framework to foster sustainable supplies from EU sources
 - Increase resource efficiency and promote recycling

Source: europa.eu

Japan

- Japan Oil, Gas, and Metals National Corporation (JOGMEC) established in 2004
 - Combining Japan National Oil Corporation (established 1967) and Metal Mining Agency of Japan (1963)
- Purpose: undertake activities to facilitate stable supplies

JOGMEC Activities

- Providing financial assistance to Japanese companies for mineral exploration and deposit development
- Gathering and analyzing information on mineral and metal markets to understand supply risk
 - Overseas geology and ore-deposit descriptions
 - Mineral policies, legislation, regulations
 - Market data and analysis
 - Mining and environment

JOGMEC (continued)

- Managing Japan's economic stockpile of 'rare' metals, defined as those both (a) essential to Japanese industry and (b) subject to significant supply instability
 - In cooperation with private Japanese firms
- Existing stocks
 - Cr, Co, Mn, Mo, Ni, W, V
 - 60 days of industrial use (42 held by JOGMEC, 18 by private Japanese firms)
 - 2005: some Ni and W released to the market
- Under observation: Ga, In, Nb, Pt, rare earths, Sr, Ta

Source: www.jogmec.go.jp